Lockheed Martin

Automated Baseline Change Detection (ABCD) for Robotic Drum Inspection

Technology Need:

Regulations require weekly inspections of thousands of barrels of mixed waste stored at Department of Energy (DOE) sites. Manual inspection processes are time consuming, of inconsistent quality, and expose humans to toxic and radioactive materials. Other DOE projects are addressing the automated acquisition of optical images and partial image analysis with the Stored Waste Autonomous Mobile Inspector (SWAMI), the Intelligent Mobile Sensor System (IMSS), and A Robotic Inspection Experimental System (AIRES), but these image analyses do not detect all potential failures.

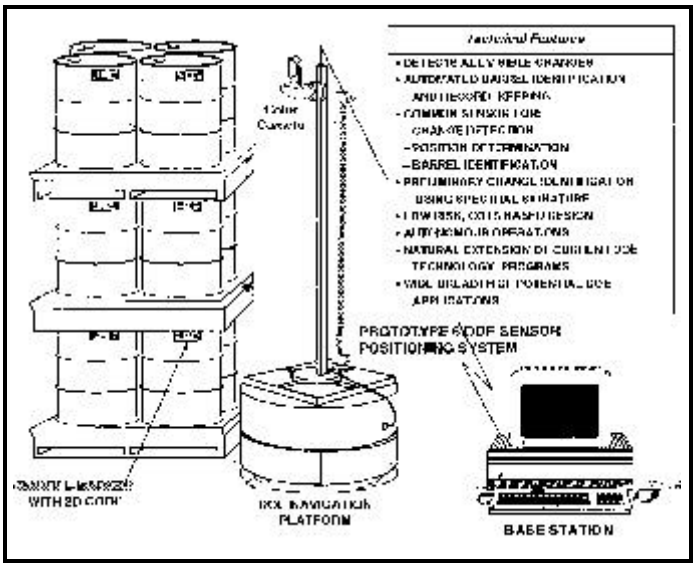


Figure 1. Components of ABCD System.

Technology Description:

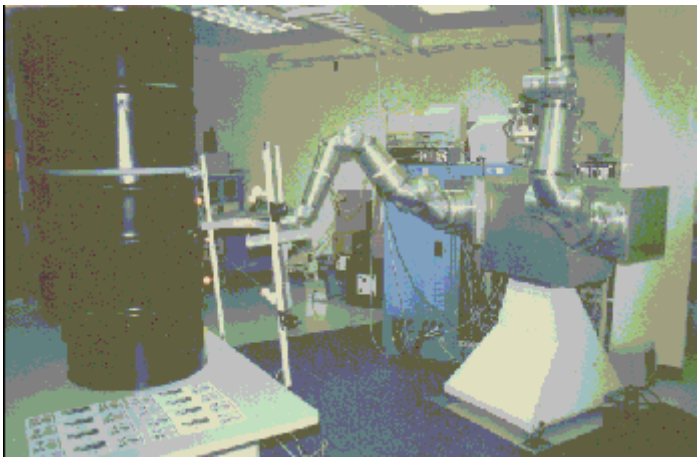
Lockheed Martin has developed a system that enhances both the reliability and validity of barrel inspection by detecting any change in the visual appearance of a barrel. This is done by comparing a current inspection image with an archived baseline image, hence the name Baseline Change Detection (BCD). Thus ABCD is not limited to only known changes. Any change, whether it is recognized as a potential hazard or not, is identified.

If further interpretative analysis, such as rust detection, verifies that the change is benign, then no further action is required. If interpretative analysis is not familiar with the observed type of change, or if the change is not benign, then human operators are notified of the potentially hazardous change. Note that depending upon operational considerations, no operator action is mandatory for benign changes. Benign changes may still be used for trend analysis.

The ABCD sensor system integrates robot control, image processing, and the Kinetic Sciences, Inc. Eagle Eye system to produce a system that acquires and identifies the target, computes sensor pose, and rapidly and precisely repositions the sensor. The ABCD project embodies two key technical strategies: (1) practical, real-time determination barrel identification with full 3-D pose (position and orientation) relative to the sensors and (2) application of image registration to change detection through sensor repositioning and image transformation to match the pose of an archived image.

The main components of the ABCD system are shown in the figure. In routine operation, the base platform moves the sensor to a stack of barrels and stops when the sensor is nearly centered on the identification and pose label. The sensor precision-positioning system repositions the camera into the same relative pose that was used for an archived reference image. A new image is compared to the baseline reference image. Because the camera is precisely repositioned the image comparison is based on image subtraction with minimal translation for registration.

Changes, if any, are compared to operational criteria. Change analysis may be performed, such as spectral analysis and image interpretation, and additional images



may be saved for later inspection and record keeping. For example, image interpretation may be used to reduce potential false positive changes.

If image interpretation concludes that the change is benign, the unit passes inspection. But if not benign or if still uncertain, then other actions, such as human notification, can be taken. In this manner, there is very low risk of inspection failure and human involvement is focused on the most important cases.

Benefits:

<Automatic detection of any visual change on the barrel surfaces
<Reduces health and safety risks to workers
<Quicker detection of leak reduces environmental risks
<Autonomous inspections reduce operations costs
<Technology increases accountability for stored wastes by creating an accurate, consistent, and frequent record
<Reliable early warning of storage problems with minimal image understanding or human inspection

Status and Accomplishments:

The project concluded in October 1997. Lockheed Martin conduct ABCD and IMSS initial field trials and demonstrations at Fernald in May - June 1996. The new ABCD image-registration decal was successfully demonstrated. IMSS collected ABCD inspection images, returned to the base station, and down-loaded the images. At a single operator's console, the ABCD images were transmitted to the collocated ABCD processor for analysis and results received back at the operator's work station for inspection. A live demonstration of ABCD with audience participation was successful and convincing of ABCD contribution to drum inspection.

After some further development and more extensive integration, the prototype was tested at the Idaho National Engineering and Environmental Laboratory's (INEEL) Radioactive Waste Management Facility (RWMC), Building 628 at beginning in April 1997. The integrated system, composed of ABCD imaging software and the IMSS mobility base, is called MISS EVE (Mobile Intelligent Sensor System- Environmental Validation Expert). Evaluation of the integrated system in RWMC Building 628, containing approximately 10,000 drums, demonstrated an easy to use system with the ability to properly navigate through the facility, image all the defined drums, and process the report delivered to the operator on a Graphic User Interface (GUI) and on hard copy. Currently, the system resides at INEEL and will be deployed at suitable sites as needed.

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Online Resources:

Office of Science and Technology, Technology Management System (TMS), Tech ID # 265
http://ost.em.doe.gov/tms

The National Energy Technology Laboratory Internet address is http://www.netl.doe.gov

For additional information, please visit the Lockheed Martin website at http://www,lockheedmartin.com/